INERTIAL CONFINEMENT FUSION
Lawrence Livermore National Laboratory
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National Ignition Facility Inertial Confinement Fusion Experiments Begin

The Inertial Confinement Fusion Program has conducted its first experiments on the National Ignition Facility (NIF), employing the first four laser beams in a single quad to measure propagation and backscatter losses in large ignition-size plasmas. Figure 1 shows a 7-mm-long gas-filled target that was heated from one side by overlapping the four beams operated at 351 nm (3ω). The beams, smoothed with continuous phase plates (CPPs) over a 500-μm spot-size, provided a total energy of 16 kJ in a 3.5-ns-long flat-topped laser pulse corresponding to an ignition-relevant intensity of 2×10^{15} W cm^{-2} on target. The targets were filled with 1 atm of CO_2 producing between 2- and 7-mm-long homogeneously heated plasmas with densities $n_e \sim 6 \times 10^{20}$ cm^{-3} and temperatures $T_e \sim 2.2$ keV as calculated by the radiation-hydrodynamic code LASNEX. The high energy in a NIF quad of beams, illuminating the target from one direction, creates unique conditions for the study of laser–plasma interactions at scale lengths not previously accessible.

The propagation through the large-scale plasma was measured with a gated x-ray imager that was filtered for 3.5-keV x-rays. Figure 2 compares the experimental data from a 7-mm-long target with the postprocessed LASNEX simulations showing initially that the beams strike the membrane of the target with a spot diameter of 500 μm as determined by the CPPs. The subsequent images show propagation of the heating wave through the plasma reaching the end of the target at 3 ns. The calculated images show close correspondence with the experimental observations, indicating that the beams interact with the full length of this ignition-scale plasma during the last ~0.5 ns of the experiment.

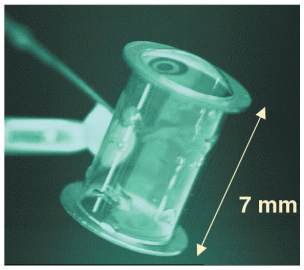

Figure 1. A 7-mm-long gas target consisting of a 100-μm-thick CH wall and 0.75-μm-thick membranes on either end holding 1 atm of CO_2.

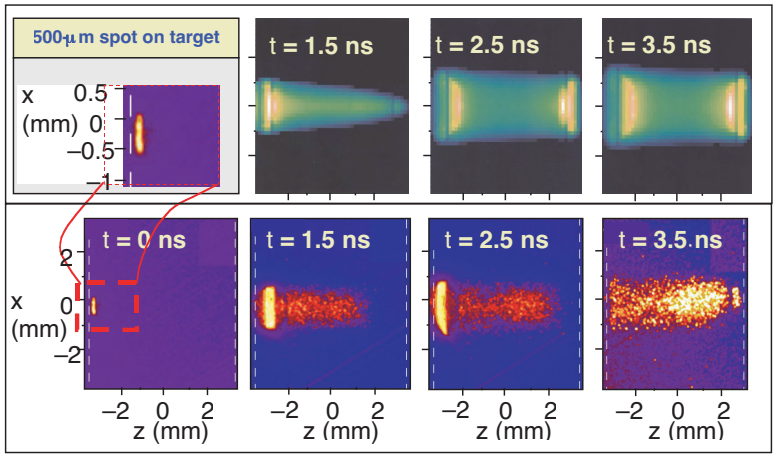

Figure 2. Gated x-ray images at various times during the experiment showing the propagation through the 7-mm plasma.

The backscatter losses were measured with the recently activated Full-Aperture Backscatter Station, which provides temporally and spectrally resolved measurements of the stimulated Raman scattering (SRS) and stimulated Brillouin scattering (SBS) back into the four focusing lenses. In these experiments we observe small SBS losses of 6% for the smallest plasma length investigated (2-mm length), increasing to 10% at the highest length of 7 mm. The spectral width of the scattering peaks (Fig. 3), which are a direct measure of the range of plasma temperatures and densities sampled, is narrow throughout the pulse and in good agreement with simulations, confirming that the beams interact with large-scale plasmas with the calculated temperatures and densities. SRS losses are negligible in these experiments. These results show for the first time the propagation of intense beams through large ignition-size plasmas. Future NIF experiments will be conducted to measure scattering around the four lenses to assess the total energy losses and the nonlinear scattering processes at ignition-size plasma lengths. As more NIF beams are activated, we will extend these measurements to higher-electron-temperature plasmas that more closely emulate ignition hohlraum conditions.

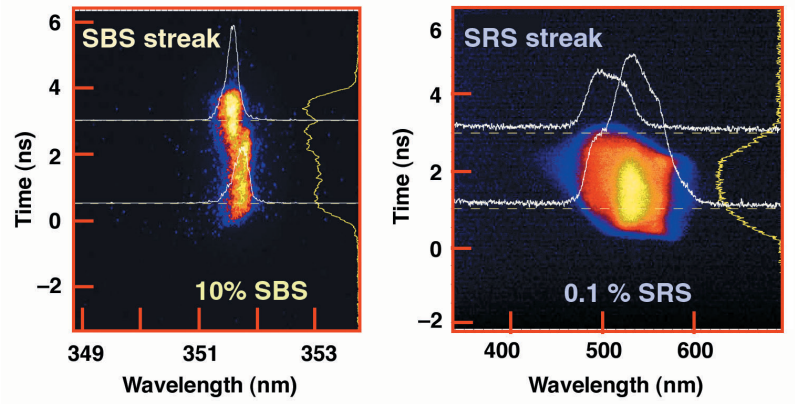

Figure 3. SBS and SRS streaked spectra indicating 10% SBS and 0.1% SRS.

For comments about content of the ***Bimonthly Update***, contact Bruce A. Hammel (925) 422-3299.
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